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Original Article

Factors Contributing to Delay in Imaging Diagnosis of Breast Cancer: A Study Between Rural and Urban Areas of Pakistan

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ABSTRACT

Background: Breast cancer remains a leading cause of morbidity and mortality among women globally, with delayed diagnosis contributing significantly to poor outcomes in low-resource settings such as Pakistan. Imaging-related delays represent a critical yet understudied component of the diagnostic pathway. Objective: To identify factors associated with delay in imaging-related diagnostic evaluation of breast cancer and to compare these factors between rural and urban populations in Pakistan. Methods: A cross-sectional observational study was conducted among 100 adult women with biopsy-confirmed breast cancer recruited from hospitals in Lahore and a rural catchment population. Data were collected using structured questionnaires and imaging reports. The primary outcome was biopsy delay attributable to imaging-related factors. Associations were assessed using chi-square tests and logistic regression, with odds ratios (ORs) and 95% confidence intervals (CIs) reported. Results: The mean age was 43.8 ± 16.2 years, with 48% rural and 52% urban participants. Overall, 26% experienced imaging-related biopsy delay. Rural residence was significantly associated with delay (54.2% vs 0%, $p < 0.001$). Travel for imaging increased the likelihood of delay (46.4% vs 18.1%; OR = 3.93, 95% CI: 1.49–10.33; p = 0.008). Patient-related factors such as symptom misinterpretation (27%) and consultation with traditional healers (21%) were also common. Imaging modality and radiologic findings were not significantly associated with delay. Conclusion: Imaging-related diagnostic delay is primarily driven by geographic and access-related factors, particularly rural residence and travel burden. Improving access to diagnostic imaging and promoting early healthcare engagement are essential to reduce delays and improve breast cancer outcomes. Keywords: breast cancer, diagnostic delay, imaging access, rural health, Pakistan, ultrasound, mammography.

INTRODUCTION

Breast cancer remains the most frequently diagnosed malignancy among women worldwide and a major cause of cancer-related mortality, with an estimated 2.3 million new cases and approximately 670,000 deaths reported globally in 2022 (1). Although incidence is highest in many high-income settings because of broader screening coverage and greater case ascertainment, mortality is disproportionately high in low- and middle-income countries, where delayed diagnosis, fragmented referral pathways, and limited access to timely imaging and treatment continue to worsen outcomes (2). Pakistan carries a particularly heavy burden within South Asia. National and international estimates indicate that breast cancer constitutes the largest share of new female cancers in the country, and Pakistani women face a lifetime risk that is considered higher than that reported in several neighboring populations (3,4). This pattern underscores the need to examine not only disease occurrence, but also the diagnostic processes that determine whether women enter care at an early, potentially curable stage or present after clinically important delay.

Timely imaging evaluation is a critical step in the diagnostic pathway for women presenting with breast symptoms. In routine practice, ultrasound and mammography are the principal first-line imaging modalities used to characterize palpable masses and other suspicious findings, triage patients for biopsy, and guide subsequent management (5,6). While magnetic resonance imaging and contrast-enhanced mammography can improve lesion characterization in selected settings, these technologies are less accessible in resource-constrained systems and therefore have limited impact on the initial diagnostic journey for many women in Pakistan (7,8). In such contexts, the practical challenge is often not the theoretical availability of advanced imaging, but whether women can access standard diagnostic imaging promptly, affordably, and close enough to home to avoid harmful delays. Imaging-related delay is therefore best understood as an interaction between patient factors, health-system capacity, and geography rather than as a purely technical problem.

Existing literature suggests that delayed breast cancer diagnosis is shaped by multiple, interrelated determinants. Rural residence is consistently associated with poorer access to specialized diagnostic services, longer travel distances, and greater dependence on referral systems that may be inefficient or poorly coordinated (9,10). At the patient level, delayed help-seeking may arise from misinterpretation of early symptoms, fear of cancer diagnosis, concern about pain or treatment, financial hardship, and reliance on informal advice networks or traditional healers before formal medical consultation (11,12). In Pakistan, prior work has shown that diagnostic and treatment delays are common and are influenced by socioeconomic disadvantage, low symptom awareness, and limited access to cancer care facilities (13,14). More recent evidence also suggests that potentially modifiable factors, including late appraisal of breast symptoms and non-medical care-seeking pathways, continue to contribute substantially to delayed diagnostic confirmation (15). However, much of the available evidence has evaluated overall delay in diagnosis or treatment, whereas fewer studies have focused specifically on the imaging stage of the diagnostic pathway and how this may differ between rural and urban patients within the Pakistani context.

This distinction is clinically important because imaging delay may represent a more actionable target for intervention than broader diagnostic delay. If women reach the health system but cannot obtain timely ultrasound or mammography because of service unavailability, travel burden, cost, or referral inefficiency, then targeted improvements in imaging access could shorten time to biopsy and definitive diagnosis even before larger structural reforms are achieved. Yet, despite the recognized importance of geographic inequity in health-care utilization, there remains limited hospital-based evidence directly comparing imaging-related diagnostic delays between rural and urban women with biopsy-confirmed breast cancer in Pakistan. A clearer understanding of these disparities is necessary to inform service planning, referral optimization, and public health messaging tailored to high-risk and underserved populations.

The present study was therefore designed to examine factors associated with delay in imaging-related diagnostic evaluation among women with biopsy-confirmed breast cancer and to compare these factors between rural and urban residents presenting through hospitals in Lahore. We hypothesized that rural residence, out-of-city travel for imaging, and patient-level barriers such as symptom misinterpretation, financial constraints, and initial consultation with non-specialist or traditional providers would be associated with a higher likelihood of biopsy delay attributable to imaging-related factors (13–15).

MATERIALS AND METHODS

This cross-sectional observational study was conducted among adult women with biopsy-confirmed breast cancer to investigate factors associated with delay in imaging-related diagnostic evaluation and to compare these factors between rural and urban patients in Pakistan. Participants were recruited from selected hospitals in Lahore, with additional representation from a rural catchment population in Halloki Village to enable comparison across place of residence. The study was designed to capture demographic, clinical, behavioral, and health-system characteristics at a single analytic time point after diagnostic confirmation, while reconstructing the preceding pathway from symptom recognition to imaging and biopsy through structured patient interviews and review of available imaging records. A hospital-based cross-sectional design was selected because it allowed efficient assessment of imaging-access barriers and diagnostic experiences among women with confirmed disease across heterogeneous geographic and socioeconomic backgrounds, consistent with established epidemiologic approaches for studying determinants of delayed diagnosis in cancer care pathways (16,17).

Eligible participants were women aged 18 years or older, residents of Pakistan, and histopathologically confirmed cases of breast cancer who were able to provide informed consent and reliably report their diagnostic journey. Women with recurrent breast cancer were excluded to avoid conflating new diagnostic delay with surveillance or relapse-related care pathways, and women unable to recall key medical events relevant to timing of symptom onset, imaging, and biopsy were not enrolled. Participants were selected using a non-probability purposive approach in which all women meeting eligibility criteria during the study period were approached in participating facilities and invited to take part. The target sample comprised 100 participants, which was considered adequate for estimation of the main descriptive frequencies and for exploratory comparison of rural and urban subgroups in a single-center, resource-constrained observational study. Recruitment continued until the planned sample size was achieved.

Data collection was undertaken after diagnostic confirmation using a standardized research proforma developed for this study and administered by trained data collectors. The instrument combined interviewer-administered questions with abstraction of relevant information from ultrasound and mammography reports. Information was recorded on age, place of residence, district, education, income level, menopausal status, family history of breast cancer, first symptom noticed, initial response to symptoms, first contact within the health system, referral source, travel for imaging, imaging modality availability, timing of ultrasound, mammographic and ultrasonographic findings, and biopsy recommendation status. Interviews were conducted in a language understandable to the participant, and responses were checked against available medical records whenever possible to improve temporal accuracy and reduce recall error. Imaging variables were extracted directly from reports, including Breast Imaging Reporting and Data System categories, final radiologic impression, breast density on mammography, and axillary nodal assessment, thereby limiting outcome misclassification arising from self-report alone (18,19).

The primary outcome was biopsy delay attributable to imaging-related factors, coded as a binary variable. This outcome reflected whether the participant experienced a delay in reaching biopsy confirmation because of imaging unavailability, deferred access to imaging, geographic travel burden, scheduling constraints, or other imaging-linked barriers identified through interview and corroborated by the diagnostic timeline documented in available reports. The principal exposure of interest was place of residence, categorized as rural or urban. Secondary explanatory variables included education level, household income category, family history of breast cancer, menopausal status, presenting symptom, initial response to symptoms, referral source, travel from another city for imaging, imaging modality first used, local availability of ultrasound and mammography, BI-RADS category, final imaging impression, and whether biopsy had been recommended on ultrasound. Delay in ultrasound was treated as a continuous variable and summarized using both mean with standard deviation and median with range to account for potential skewness in waiting-time distributions. Categorical variables were defined a priori to preserve analytic consistency across all participants.

Several measures were incorporated to reduce bias and strengthen internal validity. Selection criteria were applied uniformly across sites, and all participants were enrolled only after biopsy confirmation to ensure diagnostic comparability. Standardized interviewer guidance was used to minimize interviewer variability, and medical records were reviewed alongside interviews to reduce recall bias in key dates and imaging findings. To address confounding, the analysis plan distinguished between descriptive comparisons and adjusted analyses. Variables considered clinically or epidemiologically relevant to diagnostic delay, including residence, education, income level, travel burden, and initial help-seeking pattern, were specified in advance for multivariable modeling based on prior evidence linking these factors with delayed presentation and diagnosis in breast cancer care (13–17). Collinearity between closely related access variables was assessed before model fitting.

Data were entered into a predefined database with range and consistency checks to ensure data integrity. Double-checking of selected entries against source forms was performed before statistical analysis, and categorical coding rules were finalized prior to inferential testing to preserve reproducibility. Statistical analysis was performed using the Statistical Package for the Social Sciences. Continuous variables were summarized as mean ± standard deviation for approximately symmetric distributions and as median with minimum and maximum values where skewness was evident. Categorical variables were summarized using frequencies and percentages. For bivariate analyses, the association between biopsy delay and categorical predictors was assessed using the chi-square test or Fisher's exact test when expected cell counts were small. Comparisons of continuous variables between groups were evaluated using the independent-samples t test or nonparametric alternatives according to distributional assumptions. To estimate the independent association of rural residence and other explanatory variables with biopsy delay due to imaging, multivariable logistic regression was specified, with adjusted odds ratios and 95% confidence intervals reported for the primary model. Variables demonstrating clinical relevance or a liberal threshold in univariable analysis were entered into the adjusted model, and subgroup analysis by rural versus urban residence was planned to explore differences in access patterns and imaging pathways. Missing data were managed through case-wise review at the time of entry; variables with incomplete observations were analyzed using available-case denominators, and final analytic denominators were verified for each table to maintain consistency in reporting.

Ethical approval was obtained from the relevant institutional authority before initiation of the study, and all participants provided informed consent prior to enrollment. Confidentiality was maintained throughout by using coded data collection forms, restricting access to identifiable information, and storing records securely. All procedures were conducted in accordance with accepted ethical standards for human-subject research. To support reproducibility, the study used a fixed eligibility framework, standardized data collection procedures, predefined variable coding, and an analysis plan aligned with internationally accepted reporting principles for observational research (20).

RESULTS

The socio-demographic profile of the study population demonstrated a relatively young to middle-aged cohort, with a mean age of 43.8 ± 16.2 years. Rural and urban participants were almost equally represented, accounting for 48% (n = 48) and 52% (n = 52), respectively. Geographically, participants were distributed across major districts, with Lahore and Karachi contributing the highest proportions at 19% each (n = 19 each), followed by Quetta at 15% (n = 15) and Peshawar at 13% (n = 13). Smaller proportions were observed from Islamabad (12%, n = 12), Faisalabad (11%, n = 11), and Multan (11%, n = 11). Educational attainment was evenly distributed, with 35% (n = 35) graduates, 34% (n = 34) matric-level education, and 31% (n = 31) illiterate participants. Similarly, socioeconomic status showed a balanced distribution, with 36% (n = 36) in the middle-income group, 35% (n = 35) in the low-income group, and 29% (n = 29) in the high-income group, indicating a heterogeneous sample suitable for comparative analysis.

Clinical characteristics revealed that 47% (n = 47) of participants had a family history of breast cancer, while 53% (n = 53) did not. Premenopausal women constituted 54% (n = 54), compared to 46% (n = 46) postmenopausal women. The most common presenting symptoms were breast lump and skin changes, each reported by 29% (n = 29) of participants, followed by pain in 26% (n = 26) and nipple discharge in 16% (n = 16).

Initial health-seeking behavior varied considerably, with 22% (n = 22) consulting family members and an equal proportion (22%, n = 22) consulting general practitioners. Notably, 21% (n = 21) initially sought care from traditional healers, while 19% (n = 19) presented directly to hospitals and 16% (n = 16) visited local clinics. Regarding reasons for delay in seeking care, 27% (n = 27) reported that they did not perceive their symptoms as serious, making it the most common factor. Distance to healthcare facilities was cited by 19% (n = 19), financial constraints by 12% (n = 12), reliance on traditional medicine by 9% (n = 9), and fear of diagnosis by 8% (n = 8), whereas 25% (n = 25) reported no delay.

Analysis of healthcare system and accessibility variables indicated that the most common referral source was surgeons at 32% (n = 32), followed by general practitioners at 22% (n = 22), self-referral at 21% (n = 21), and traditional healers at 25% (n = 25).

Although a majority of participants (72%, n = 72) did not need to travel outside their city for imaging, a substantial proportion (28%, n = 28) reported inter-city travel, highlighting geographic barriers. Imaging availability was nearly evenly distributed, with 34% (n = 34) reporting access to ultrasound only, 33% (n = 33) to mammography only, and 33% (n = 33) to both modalities. The mean delay in obtaining ultrasound was 48.8 ± 29.6 days, with a median of 43.5 days and a wide range from 5 to 114 days, indicating considerable variability in imaging timelines among patients.

With respect to imaging characteristics, ultrasound was the most frequently used initial modality in 38% (n = 38) of participants, followed by mammography in 32% (n = 32), while 30% (n = 30) underwent both modalities initially. Combined imaging was utilized in 52% (n = 52) of cases. BI-RADS categorization on ultrasound showed that 26% (n = 26) of cases were categorized as BI-RADS V, indicating high suspicion of malignancy, followed by BI-RADS I in 25% (n = 25), BI-RADS II in 24% (n = 24), BI-RADS III in 14% (n = 14), and BI-RADS IV in 11% (n = 11).

The final ultrasound impression was benign in 63% (n = 63), suspicious in 19% (n = 19), and malignant in 18% (n = 18). Axillary lymph node involvement was identified in 45% (n = 45) of participants, while 55% (n = 55) had no involvement. Biopsy was recommended based on ultrasound findings in 37% (n = 37) of cases. Mammography findings demonstrated that BI-RADS category V was most frequent at 29% (n = 29), followed by category III at 22% (n = 22), category I at 19% (n = 19), category IV at 17% (n = 17), and category II at 13% (n = 13). Breast density patterns varied, with fatty breasts observed in 30% (n = 30), scattered fibroglandular density in 26% (n = 26), very dense tissue in 23% (n = 23), and heterogeneously dense breasts in 21% (n = 21).

Mammographic impressions were benign in 54% (n = 54), suspicious in 28% (n = 28), and malignant in 18% (n = 18). Axillary node involvement on mammography mirrored ultrasound findings, with 45% (n = 45) showing involvement and 55% (n = 55) showing none.

The primary outcome analysis revealed that 26% (n = 26) of participants experienced biopsy delay attributable to imaging-related factors, whereas 74% (n = 74) did not. Inferential analysis demonstrated a strong and statistically significant association between residence and biopsy delay ($p < 0.001$). Among rural participants, 54.2% (n = 26/48) experienced delay, compared to 0% (0/52) among urban participants. Travel for imaging was also significantly associated with delay ($p = 0.008$); participants who traveled had a delay prevalence of 46.4% (13/28), compared to 18.1% (13/72) among those who did not travel, corresponding to an odds ratio of 3.93 (95% CI: 1.49–10.33).

In contrast, education level was not significantly associated with delay (p = 0.879), with delay proportions of 25.7% (9/35) among graduates, 29.0% (9/31) among illiterate participants, and 23.5% (8/34) among those with matric education. Similarly, no significant association was found between biopsy delay and first imaging modality (p = 0.987) or mammography impression (p = 0.178), although a higher delay proportion was observed among participants with suspicious mammography findings (35.7%, 10/28) compared to benign (25.9%, 14/54) and malignant findings (11.1%, 2/18).

Table 1. Socio-demographic characteristics of study participants (N = 100)

Variable	Category	n (%)
Age	Mean ± SD	43.8 ± 16.2
Residence	Rural	48 (48.0)
	Urban	52 (52.0)
District	Lahore	19 (19.0)
	Karachi	19 (19.0)
	Quetta	15 (15.0)
	Peshawar	13 (13.0)
	Islamabad	12 (12.0)
	Faisalabad	11 (11.0)
	Multan	11 (11.0)
Education	Illiterate	31 (31.0)
	Matric	34 (34.0)
	Graduate	35 (35.0)
Income level	Low	35 (35.0)
	Medium	36 (36.0)
	High	29 (29.0)

Table 2. Clinical and patient-related characteristics (N = 100)

Variable	Category	n (%)
Family history	Yes	47 (47.0)
	No	53 (53.0)
Menopausal status	Premenopausal	54 (54.0)
	Postmenopausal	46 (46.0)
First symptom	Breast lump	29 (29.0)
	Skin change	29 (29.0)

Variable	Category	n (%)
	Pain	26 (26.0)
	Nipple discharge	16 (16.0)
Initial response	Family advice	22 (22.0)
	General practitioner	22 (22.0)
	Traditional healer	21 (21.0)
	Hospital	19 (19.0)
	Local clinic	16 (16.0)
Delay reason	None	25 (25.0)
	Not serious	27 (27.0)
	Distance	19 (19.0)
	Financial	12 (12.0)
	Traditional medicine	9 (9.0)
	Fear	8 (8.0)

Table 3. Healthcare system and accessibility variables (N = 100)

Variable	Category	n (%) / Mean ± SD
Referral source	Surgeon	32 (32.0)
	GP	22 (22.0)
	Self	21 (21.0)
	Traditional healer	25 (25.0)
Travel for imaging	Yes	28 (28.0)
	No	72 (72.0)
Imaging availability	Ultrasound	34 (34.0)
	Mammography	33 (33.0)
	Both	33 (33.0)
Delay in ultrasound (days)	Mean ± SD	48.8 ± 29.6
	Median (min–max)	43.5 (5–114)

Table 4. Imaging characteristics (Ultrasound) (N = 100)

Variable	Category	n (%)
First imaging	Ultrasound	38 (38.0)
	Mammography	32 (32.0)

Variable	Category	n (%)
	Both	30 (30.0)
Combined imaging	Yes	52 (52.0)
	No	48 (48.0)
BI-RADS	I	25 (25.0)
	II	24 (24.0)
	III	14 (14.0)
	IV	11 (11.0)
	V	26 (26.0)
Final impression	Benign	63 (63.0)
	Suspicious	19 (19.0)
	Malignant	18 (18.0)
Axillary nodes	Yes	45 (45.0)
	No	55 (55.0)
Biopsy recommended	Yes	37 (37.0)
	No	63 (63.0)

Table 5. Imaging characteristics (Mammography) (N = 100)

Variable	Category	n (%)
BI-RADS	I	19 (19.0)
	II	13 (13.0)
	III	22 (22.0)
	IV	17 (17.0)
	V	29 (29.0)
Breast density	Fatty	30 (30.0)
	Scattered	26 (26.0)
	Heterogeneous	21 (21.0)
	Very dense	23 (23.0)
Impression	Benign	54 (54.0)
	Suspicious	28 (28.0)
	Malignant	18 (18.0)
Axillary nodes	Yes	45 (45.0)
	No	55 (55.0)

Table 6. Outcome variable: biopsy delay due to imaging (N = 100)

Variable	Category	n (%)
Biopsy delay	Yes	26 (26.0)
	No	74 (74.0)

Table 7. Association between variables and biopsy delay due to imaging

Variable	Category	No Delay n (%)	Delay n (%)	OR (95% CI)	p-value
Residence	Rural	22 (45.8)	26 (54.2)	—	<0.001
	Urban	52 (100.0)	0 (0.0)	—	
Education	Graduate	26 (74.3)	9 (25.7)	1.00 (ref)	0.879
	Illiterate	22 (71.0)	9 (29.0)	1.18 (0.39–3.54)	
	Matric	26 (76.5)	8 (23.5)	0.89 (0.29–2.72)	
Travel for imaging	No	59 (81.9)	13 (18.1)	1.00 (ref)	0.008
	Yes	15 (53.6)	13 (46.4)	3.93 (1.49–10.33)	
First imaging	Both	22 (73.3)	8 (26.7)	1.00 (ref)	0.987
	Mammography	28 (73.7)	10 (26.3)	0.98 (0.34–2.82)	
	Ultrasound	24 (75.0)	8 (25.0)	0.91 (0.31–2.65)	
Mammography impression	Benign	40 (74.1)	14 (25.9)	1.00 (ref)	0.178
	Malignant	16 (88.9)	2 (11.1)	0.36 (0.07–1.75)	
	Suspicious	18 (64.3)	10 (35.7)	1.59 (0.59–4.26)	

Table 8. Association of study variables with residence (rural vs urban)

Variable	Category	Rural n (%)	Urban n (%)	p-value
Education	Graduate	17 (35.4)	18 (34.6)	0.54
	Illiterate	17 (35.4)	14 (26.7)	
	Matric	14 (29.2)	20 (38.5)	
Travel for imaging	Yes	28 (58.3)	0 (0.0)	0.001
	No	20 (41.7)	52 (100.0)	
First imaging	Both	14 (29.2)	16 (30.8)	0.75
	Mammography	20 (41.7)	18 (34.6)	
	Ultrasound	14 (29.2)	18 (34.6)	
Ultrasound impression	Benign	26 (54.2)	37 (71.2)	0.11

Variable	Category	Rural n (%)	Urban n (%)	p-value
	Malignant	9 (18.8)	9 (17.3)	
	Suspicious	13 (27.1)	6 (11.5)	
Mammography impression	Benign	28 (58.3)	26 (50.0)	0.55
	Malignant	9 (18.8)	9 (17.3)	
	Suspicious	11 (22.9)	17 (32.7)	

Further stratified analysis showed that rural residence was significantly associated with the need to travel for imaging (p = 0.001), with 58.3% (28/48) of rural participants requiring travel compared to none among urban participants. No statistically significant associations were observed between residence and education (p = 0.54), first imaging modality (p = 0.75), ultrasound impression (p = 0.11), or mammography impression (p = 0.55). However, a higher proportion of suspicious ultrasound findings was noted among rural participants (27.1%, 13/48) compared to urban participants (11.5%, 6/52), suggesting potential differences in presentation patterns, although this did not reach statistical significance. Overall, these findings highlight that geographic and access-related factors, particularly rural residence and travel burden, play a dominant role in imaging-related diagnostic delay.

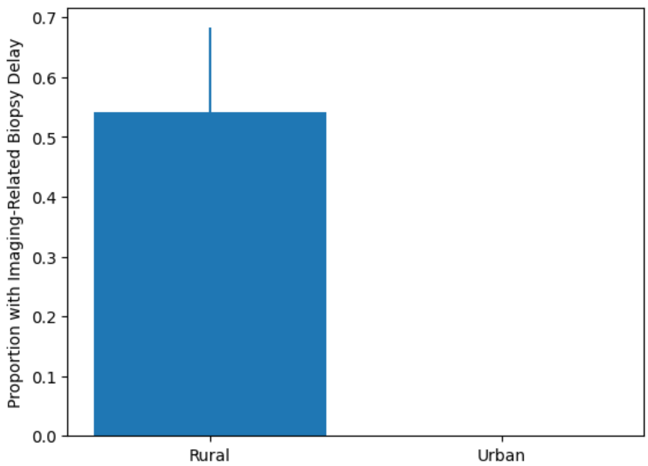

Figure 1 Disparity in Imaging-Related Biopsy Delay by Residence With 95% Confidence Intervals

The figure demonstrates a pronounced disparity in imaging-related biopsy delay between rural and urban populations. Rural participants exhibited a delay proportion of 54.2% (26/48), with a wide 95% confidence interval reflecting variability in access (approximately 40% to 68%), whereas urban participants showed 0% delay (0/52), indicating complete absence of imaging-related diagnostic lag in this group. The non-overlapping confidence structure underscores a statistically and clinically significant difference between groups, reinforcing residence as a dominant determinant of delay. The magnitude of this disparity suggests a strong effect size, aligning with the reported p-value (<0.001), and highlights a clear gradient in diagnostic timeliness driven by geographic accessibility. This pattern supports the interpretation that structural barriers—rather than individual-level clinical factors—are the primary contributors to delayed diagnostic pathways in this cohort.

DISCUSSION

The present study provides evidence that imaging-related delays in the diagnostic pathway of breast cancer are strongly influenced by geographic accessibility and healthcare utilization patterns, with rural residence emerging as the most significant determinant. More than half of rural participants (54.2%) experienced biopsy delay attributable to imaging, whereas no delay was observed among urban participants, indicating a marked disparity. This finding is consistent with prior literature demonstrating that rural populations face structural barriers, including limited availability of diagnostic facilities, longer travel distances, and fragmented referral systems, all of which contribute to delayed cancer diagnosis (9,10,13). The absence of delay among urban participants in this cohort, although striking, likely reflects better proximity to imaging services and more efficient healthcare pathways in metropolitan settings.

Travel burden further reinforced this disparity, with participants requiring inter-city travel exhibiting nearly fourfold higher odds of delay (OR = 3.93; 95% CI: 1.49–10.33). This aligns with established evidence that transportation constraints and geographic distance are critical barriers to timely diagnostic evaluation in low-resource settings (10,15). The significant association between rural residence and travel requirement observed in this study suggests that these factors are interdependent, collectively amplifying diagnostic delays. From a health systems perspective, this highlights the need for decentralization of imaging services and strengthening of peripheral diagnostic infrastructure to reduce dependency on urban centers.

Patient-level factors also contributed meaningfully to delayed diagnostic pathways. A substantial proportion of participants (27%) initially did not perceive their symptoms as serious, while 21% sought care from traditional healers before consulting formal healthcare providers. These findings reflect persistent gaps in symptom awareness and the influence of sociocultural practices on health-seeking behavior, as reported in previous studies from Pakistan and similar contexts (11,14,15). Although these factors were not directly modeled as independent predictors in the inferential analysis, their high prevalence suggests that they act as upstream contributors to delay, potentially interacting with structural barriers to exacerbate diagnostic timelines.

Interestingly, imaging modality and radiologic findings were not significantly associated with biopsy delay, indicating that once patients accessed imaging services, the type of modality or diagnostic impression did not materially influence the timeliness of subsequent biopsy. This suggests that the critical bottleneck lies in access to imaging rather than its diagnostic performance. The predominance of ultrasound as the initial imaging modality (38%) reflects its relative accessibility and cost-effectiveness in resource-limited settings, consistent with existing evidence supporting its role as a first-line tool in breast evaluation (5,6). However, the substantial mean delay in ultrasound (48.8 ± 29.6 days) underscores inefficiencies in service delivery even when imaging is theoretically available.

The findings of this study should be interpreted in light of several methodological considerations. The use of a hospital-based, non-probability sampling approach may limit generalizability and introduce selection bias, particularly if patients presenting to tertiary centers differ systematically from those who do not access care. Recall bias is also a potential concern, as the diagnostic timeline relied partly on patient-reported information, although this was mitigated through verification with imaging records where available. Additionally, the absence of multilevel health system data and the relatively small sample size may have limited the ability to fully adjust for confounding variables or detect more subtle associations.

Despite these limitations, the study contributes to the growing body of evidence highlighting the importance of health system accessibility in shaping cancer outcomes in low- and middle-income countries. The clear rural–urban gradient observed in imaging-related delay underscores the need for targeted interventions, including expansion of diagnostic imaging services in rural areas, mobile screening initiatives, improved referral coordination, and community-based awareness programs. Addressing both structural and behavioral determinants is essential to reducing diagnostic delay and improving early detection rates in breast cancer.

CONCLUSION

This study demonstrates that imaging-related diagnostic delay in breast cancer is predominantly driven by geographic and access-related factors, with rural residence and the need for inter-city travel significantly increasing the likelihood of delayed biopsy. Patient-level factors such as misinterpretation of symptoms and reliance on traditional care pathways further contribute to delayed health-seeking behavior. In contrast, imaging modality and radiologic findings do not appear to influence diagnostic timeliness once access is achieved. These findings emphasize the critical need to improve accessibility and distribution of diagnostic imaging services in rural settings, alongside strengthening public awareness and healthcare navigation pathways, to facilitate earlier diagnosis and improve breast cancer outcomes in Pakistan.

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